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Injury 54 (2023) 110766

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

The COVID-19 pandemic and its impacts on mass shootings in six major US cities☆,*,**

Alison Smith [a,*], Taylor Fitzpatrick-Schmidt [a], Kaylin Beiter [a], Alexander C. Cavalea [b], Peter Scharf [a], Jonathan Schoen [a], Lance Stuke [a], Patrick Greiffenstein [a], Alan Marr [a], Alexandra Tedesco [c], John P. Hunt [a]

[a] Department of Surgery, Louisiana State University Health Sciences Center, USA
[b] University of Tennessee Graduate School of Medicine – Knoxville, TN, USA
[c] Tufts Medical Center, Boston, MA, USA

ARTICLE INFO

Keywords:
Mass shootings
COVID-19
Pandemic
Urban violence

ABSTRACT

Background: The COVID-19 pandemic has significant impacts on the US socioeconomic structure. Gun violence is a major public health issue and the effects on this area have not been well-elucidated. The objective of this study was to determine the impacts of the pandemic on mass shootings in six major United States cities with historically high rates of gun violence.

Methods: Mass shooting data were extracted from an open-source database, Gun Violence Archive. Mass shooting was defined as four or more people shot at a single event. Data from six cities with the highest incidence of mass shootings were analyzed in 2019 versus 2020 (Baltimore, Chicago, Detroit, New Orleans, Philadelphia, and St. Louis). Geographic data were examined to assess changes in each city's mass shooting geographic distribution over time. Quantitative changes were assessed using the Area Deprivation Index (ADI), and qualitative data were assessed using ArcGIS.

Results: In 2020, the overall percentage of mass shootings increased by 46.7% though there was no change in the distribution of these events when assessed quantitatively (no change in average ADI) nor qualitatively (using ArcGIS). In the six cities analyzed, the total proportion of mass shooting events was unchanged during the pandemic (21.8% vs 20.6%, $p = 0.64$). Chicago, the US city with the highest incidence of mass shootings, did not experience a significant change in 2020 ($n = 34/91$, 37.3% vs. $n = 53/126$, 42.1%, $p = 0.57$). Baltimore had a significant decrease in mass shooting events ($n = 18/91$, 19.8% vs. 10/126, 7.9%, $p = 0.01$). The other four cities had no significant change in the number of mass shootings ($p>0.05$).

Conclusion: This study is the first to use ArcGIS technology to describe the patterns of mass shooting in six major US cities during the COVID-19 pandemic. The number of mass shootings in six US cities remained largely unchanged which suggests that changes in mass shootings is likely occurring in smaller cities. Future studies should focus on the changing patterns of homicides in at-risk communities and other possible social influences.

Background

Despite a decrease in trauma center volume, a rise in penetrating trauma from firearms has been observed in major United States cities during the COVID-19 pandemic [1–8]. These changes in gun violence during the lockdown from the pandemic could be attributable to financial insecurity, housing instability, and social isolation [9,10]. An increase in gun sales in the United States has also been reported [11,12].

☆ Conflicts of Interest: AS is a paid consultant for Aroa Biologics. PG is a paid consultant and speaker for Zimmer Biomet and DePuy Synthes. The other authors declare no conflicts of interest. * Funding Sources: None ** Presentation: This research was presented as a poster at the 2021 80th Annual Meeting of AAST, September 29-October 2, 2021, in Atlanta, GA.

* Corresponding author at: Clinical Surgery, Louisiana State University, Department of Surgery, 1542 Tulane Ave, Room 751, New Orleans, LA 70112, USA.
E-mail addresses: asmi60@lsuhsc.edu (A. Smith), tfitzp@lsuhsc.edu (T. Fitzpatrick-Schmidt), kbeite@lsuhsc.edu (K. Beiter), accavalea@utmck.edu (A.C. Cavalea), pschar@lsuhsc.edu (P. Scharf), jschoe@lsuhsc.edu (J. Schoen), lstuke@lsuhsc.edu (L. Stuke), pgreif@lsuhsc.edu (P. Greiffenstein), amarr@lsuhsc.edu (A. Marr), atedesco6@gmail.com (A. Tedesco), jhunt2@lsuhsc.edu (J.P. Hunt).

https://doi.org/10.1016/j.injury.2023.04.053
Accepted 29 April 2023
Available online 30 April 2023
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However, despite anecdotal suggestions of increased violence, the direct impacts of the pandemic on larger patterns of violence remain unclear in the literature.

In order to better characterize and to develop strategies to combat the evolving societal dynamics as a result of the pandemic, it is important to determine trends attributable to different types of gun violence. Mass shootings represent a specific type of gun violence that remains poorly studied [13] Over the past thirty years, mass shootings have been increasing in the United States [14]. The reasons for this uptick of mass shootings in recent decades have not yet been well-elucidated. A recent study by Pena and Anupam found that the number of mass shootings increased during the pandemic generally, though their study did not elucidate pattern changes in geographically populated areas [15]. The objective of this study was to determine the impacts of the pandemic on mass shootings in six major United States cities with historically high rates of gun violence. It was hypothesized that patterns of mass shootings followed the trend of increased gun violence during the COVID-19 pandemic.

Methods

Gun violence archive database

Information was gathered from the Gun Violence Archive (GVA), an online, open-source database run by a non-profit organization that compiles data on gun violence episodes from over 7500 sources, including law enforcement, government, media, and commercial reporting [16]. The GVA maintains the most inclusive definition of mass shootings of the FBI and other major gun violence databases [17]. The GVA has been used by other previous studies to study mass shootings [13,15].

Data collection

Mass shootings from 01/01/2019 to 12/31/2020 were selected from the GVA. Incident date, physical address of the incident, type of place where the incident occurred, number killed or injured, race and gender of those injured or killed, number of perpetrators, and race and gender of the perpetrators were extracted from the GVA database and the FBI [16,18]. The time of day and type of place where the incident occurred were also recorded. Additional data were collected including gang-related activity, drugs, or domestic violence, if the perpetrator had a previous firearm-related felony, drive-by shooting, arrest data for the perpetrators, and the type of firearm used. Not all datapoints were available for every incident.

Data were recorded for six major cities across the United States: Baltimore, Chicago, Detroit, New Orleans, Philadelphia, and St. Louis. These cities were selected because they had the highest incidence of mass shootings from 2015 to 2018. Data from 2019 was assessed in comparison to 2020 in order to evaluate year-to-year changes at the city level.

Area deprivation index: quantitative assessment of violence patterns

The Area Deprivation Index (ADI) was used to assess the socio-environmental context in which each mass shooting occurred. The ADI is a nationally standardized composite measure of 17 social indicators, including poverty, education, insurance, and race data from the US Census Bureau and the American Community Survey [19]. Address data from each mass shooting incident were used to quantify the social environment, via the ADI database. Average ADI ranking for the location of mass shooting events between 2019 and 2020 were assessed overall and at the city level.

Data visualization: qualitative assessment of violence patterns

Data were assessed visually using ArcGIS online software. Maps were developed at the city-level, with individual markers placed on the map to indicate the exact location and year (color; 2019 in white and 2020 in black) of each mass shooting incident. Distribution of mass shooting incidents between 2019 and 2020 were then compared visually in each of the six cities studied in order to qualitatively assess trends in violence pre and during the first year of the Covid-19 pandemic.

Statistical analyses

Bivariate analyses were performed to assess the differences in the proportion of mass shooting incidents occurring at each of the six cities studied. Comparisons were additionally made regarding the demographics and number of individuals killed or injured per event. The proportion of mass shootings occurring in each city versus nation-wide in 2019 versus 2020 were assessed using Chi-square analyses.

Results

Gun violence before and after COVID-19

The total number of shooting victims in 2019 increased from 69,777 to 83,206 in 2020. The total number of deaths attributable to gun violence also increased during the pandemic (39, 580 vs 43,674) as did number of people injured (30,197 vs 39, 532).

The combined total number of shootings from six major U.S. cities (6432 vs. 9139) increased by 29.6% from 2019 to 2020. The total number of shootings increased most substantially in Detroit (581 vs. 1419, 144.2%). Other cities that saw increases included: Philadelphia (1263 vs. 1930, 52.8%), Chicago (2288 vs. 3453, 50.9%), St. Louis (791 vs. 911, 15.2%), and New Orleans (519 vs 568, 9.4%). Only Baltimore had a decrease in overall shootings (990 vs 858, −13.3%).

Overall number of mortalities associated with gun violence was 1575 patients in 2019 compared to 2200 patients in 2020. Of the six major U. S. cities, the total number of deaths due to shootings increased in Philadelphia (281 vs. 444, 58.0%), Chicago (451 vs. 711, 57.6%), Detroit (170 vs. 243, 42.9%), St. Louis (257 vs. 344, 33.9%), and New Orleans (118 vs 177, 33.3%). Baltimore had a decrease in overall mortality by (298 vs 281, −5.7%) Fig. 1.

Mass shooting patterns

The total number of mass shootings in the United States in 2020 was 611, up from 417 total shootings in 2019 which represents a 46.5% increase during the COVID-19 pandemic. The collective proportion of mass shooting events in the six cities analyzed remained unchanged (n = 91/417, 21.8% vs n = 126/611, 20.6%, p = 0.71). Chicago had the highest incidence of mass shootings without a significant change (n = 34/417, 8.2% vs. 53/611, 8.7% p = 0.79). Baltimore had a significant decrease in mass shooting events during the pandemic (n = 18/417, 19.8% vs. 10/611, 7.9%, p = 0.01). The other four cities had no significant change in the number of mass shooting events (p>0.05) Table 1.

Shooting characteristics

There was no difference between 2019 and 2020 in the number of drive-by mass shootings, number of perpetrators, or timing of arrest for the perpetrator (p>0.05). There was also no difference in the type of weapon used for the shooting (p>0.05), however a significant amount of this information was not available from GVA. Handguns were the most common type of weapon used for mass shootings. During 2020, there were significantly fewer mass shootings at night compared to pre-pandemic (n = 30/611, 4.9% vs. n = 34/417, 8.2%, p = 0.04). During the pandemic, more mass shootings occurred in a store or business (n =

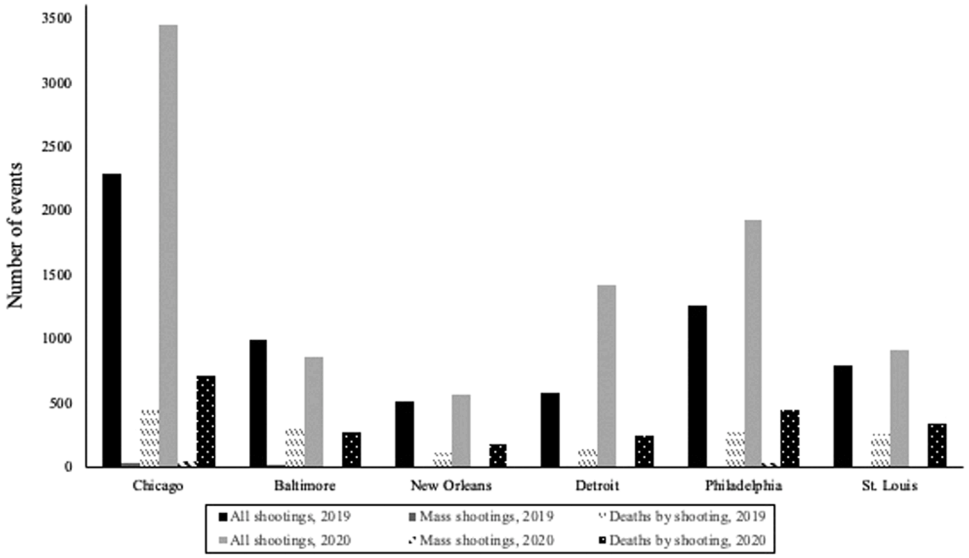

Fig. 1. Number of total shooting events, mass shooting events, and homicides for six major US cities comparing 2019 to 2020.

Table 1
Total number of mass shootings in 2019 compared to 2020 in six major United States cities.

Location	Number of mass shooting, 2019 $n = 417$	Number of mass shootings, 2020 $n = 611$	p value
Top 6 Cities (total)	91	126	0.71
Chicago	34	53	0.79
Baltimore	18	10	0.01
New Orleans	8	10	0.74
Detroit	4	10	0.36
Philadelphia	14	31	0.21
St. Louis	13	12	0.25

13/611, 2.1% vs 1/417, 0.2%, $p = 0.01$) while street/outdoor event mass shootings were more common prior to 2020 ($n = 77/611$, 12.6% vs. $n = 72/417$, 17.3%, $p = 0.04$) Table 2.

Shooting victims

Overall, there was no difference in the total number of people killed in mass shootings during the start of the COVID-19 pandemic ($n = 71/417$, 17.0% vs. $n = 81/611$, 13.3%, $p = 0.92$) or the average number of people killed per incident (1.6 vs 1.6, $p = 1.0$). The total number of injured victims did not change during the pandemic ($n = 392/417$, 94.0% vs. $n = 555/611$, 90.8%, $p = 0.59$). The average number of people injured per incident decreased from 4.3 in 2019 to 4.1 in 2020, however these changes were not significant ($p>0.05$). There was no significant difference in the gender of victims killed or injured ($p>0.05$) Table 3.

City-specific outcomes

Overall, there was no difference in the ADI ranking (mean +/- standard deviation) of the locations of mass shooting events between 2019 (73.8 +/- 24.7) and 2020 (74.2 +/- 22.8) ($p = 0.38$). Additionally, no change occurred in ADI when stratified by city: (St. Louis: $p = 0.80$, Philadelphia: $p = 0.39$, New Orleans: $p = 0.86$, Detroit: $p = 0.44$, Chicago: $p = 0.36$, Baltimore: $p = 0.09$). Maps of mass shooting incidents in each city demonstrated similar overlap of locations for St. Louis and Chicago, with least clustering year to year in Detroit and New Orleans suggesting more variability in the location of mass shooting events Fig. 2.

Table 2
Mass shooting information and shooter characteristics for six major US cities.

Shooting Information	2019 $n = 417$	2020 $n = 611$	p value
Drive-by, n (%)	22 (5.3)	36 (5.9)	0.78
Multiple perpetrators, n (%)	11 (2.6)	21 (3.4)	0.58
Perpetrator arrested after the event, n (%)	14 (3.4)	17 (2.8)	0.58
Perpetrator arrested later, n (%)	11 (2.6)	10 (1.6)	0.27
Perpetrator escaped, n (%)	75 (18.0)	110 (18.0)	1.0
Type of weapon			
Handgun, n (%)	5 (1.2)	4 (0.7)	0.50
rifle, n (%)	4 (1.0)	4 (0.7)	0.72
semiautomatic, n (%)	2 (0.5)	4 (0.7)	1.0
Weapon-automatic, n (%)	1 (0.2)	0	0.41
Unknown, n (%)	405 (97.1)	599 (98.0)	0.40
Time of day			
Morning (6AM-12PM), n (%)	4 (1.0)	1 (0.2)	0.16
Afternoon (12PM-6PM), n (%)	14 (3.4)	18 (2.9)	0.72
Evening (6PM-12AM), n (%)	38 (9.1)	73 (11.9)	0.15
Night (12AM-6AM), n (%)	34 (8.2)	30 (4.9)	*0.04*
Unknown, n (%)	327 (78.4)	489 (80.0)	0.53
Location			
Apartment/house, n (%)	8 (1.9)	25 (4.1)	0.07
Bar, n (%)	4 (1.0)	3 (0.5)	0.45
Car/bus, n (%)	0	4 (0.7)	0.15
Park/playground, n (%)	4 (1.0)	2 (0.3)	0.23
School, n (%)	1 (0.2)	0	0.41
Store/business, n (%)	1 (0.2)	13 (2.1)	*0.01*
Street/outdoor event, n (%)	72 (17.3)	77 (12.6)	*0.04*
Unknown, n (%)	327 (78.4)	487 (79.7)	0.64

Discussion

Gun violence remains a major public health threat and the impacts of the COVID-19 pandemic on this type of violence have not been well-elucidated. This study found an increase in the number of mass shooting incidents in the United States during the COVID-19 pandemic with no change in the relative distribution of mass shooting incidents across the most heavily-impacted cities. This consistent rise of violent crime indicates that the pandemic has not had an explicitly disproportionate impact upon mass shooting events in any particular geographic locale nor disproportionately changed among urban communities with high versus low levels of incivilities (according to ADI rating). It remains difficult to determine what impact the COVID-19 pandemic directly had on the overall trend of mass shootings [14].

Table 3
Total number of mortalities and injuries from mass shootings pre and post COVID-19 pandemic.

		2019 n = 417		2020 n = 611			
	Total n	%	Mean (SD) per incident	Total n	%	Mean (SD) per incident	p value
Killed All	71	17.0	1.6	81	13.3	1.6	0.92
Females	10	2.4	1.3	11	1.8	1.1	0.55
Males	61	14.6	1.5	70	11.5	1.5	0.99
Injured All	392	94.0	4.3	555	90.8	4.1	0.59
Females	90	21.6	2.0	133	21.8	1.9	0.67
Males	275	65.9	3.2	555	90.8	3.1	0.37

The sharp increase of mass shootings in 2020 relative to 2019 remains concerning, particularly given the historic link between mass shooting events and increased subsequent firearm sales [20]. Taking into account the results of this study, patterns of gun violence and gun ownership will likely also shift long-term following the COVID-19 pandemic [12].

Theoretical models surrounding the precipitants of mass shootings include perpetrator poor mental health, toxic masculinity, and contagion effects [21]. Empirical work has demonstrated worsening of mental health at the population level, [22] and theoretical arguments have been explored for changing trends in masculinity during the pandemic [23]. Additional in-depth study of these intercalating factors is crucial to understanding the dramatic increase in violence incidence, and to advance causal theories of mass shooting incidents to comprehensive (observational) experimental analysis. Until such work is accomplished regarding the core motivators for mass shooting events, policymakers should heed the findings of previous research examining the permissive factors that facilitate such occurrences [24]. While the absolute number of mass shooting events and victims increased in 2020, the average number of individuals killed or injured per incident did not change. This unrelenting human cost in addition to the direct viral mortality of the pandemic underscores the importance of rapid implementation and scale-up of existing evidence-based interventions for gun violence prevention.

This study has several limitations which merit further discussion. The retrospective nature of the study introduces inherent bias. Next, a substantial amount of data was missing from the GVA source including patient demographics and specifics on the shooter. Additional information was supplemented through dedicated internet search (i.e., media reporting on each event), however not all details were available. Next, the definition of mass shooting across databases is not consistent. The GVA was selected for use in this study because it provides the most inclusive definition of a mass shooting event. While stricter definitions of mass shootings (e.g., four or more individuals killed versus four injured or killed) would provide a more specific assessment of absolute human life cost, use of the GVA more accurately assesses changes in violence overall given the inclusion of non-fatal mass shooting events. This study was also intentionally limited to the top six cities with mass shootings in 2019 and 2020. Patterns in cities with lower burden of mass shooting

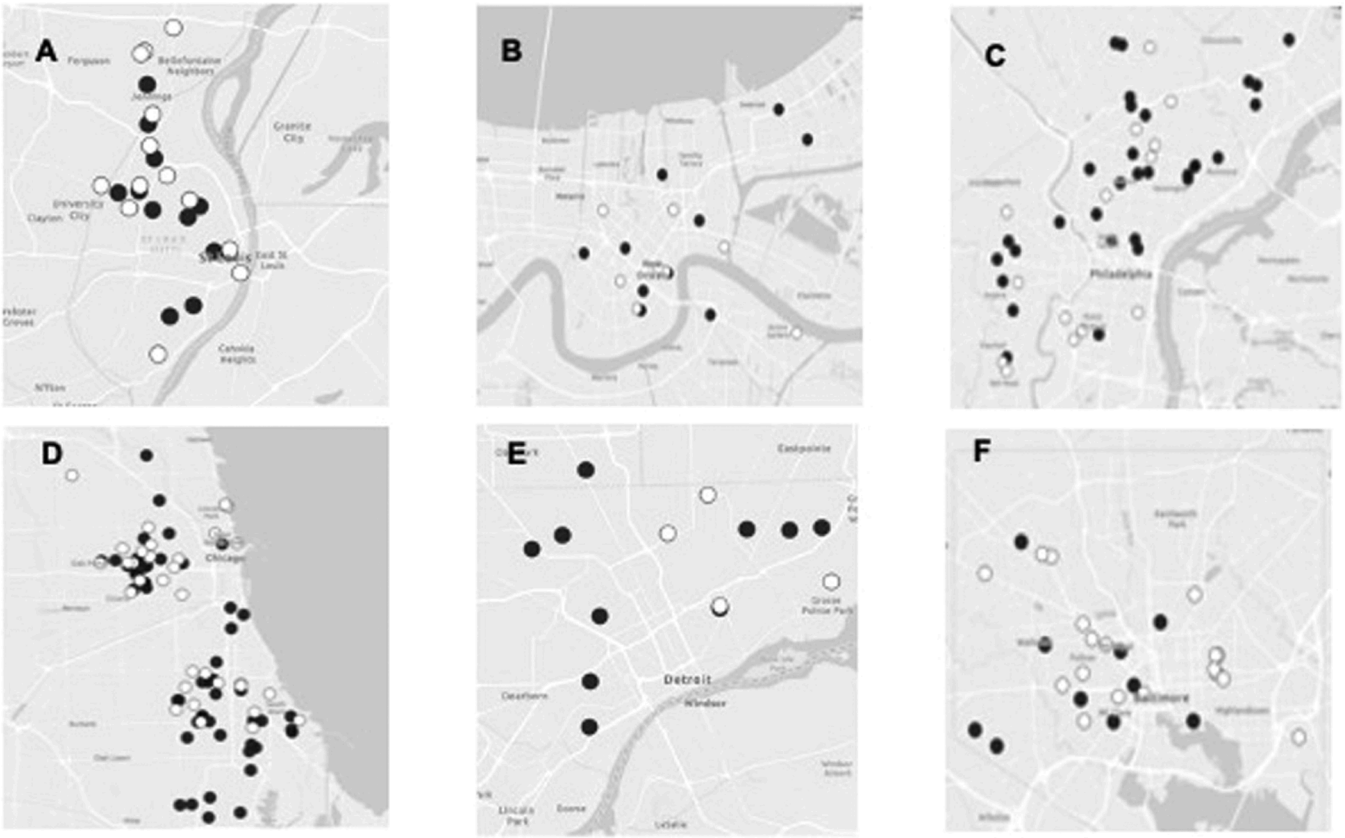

Fig. 2. Geographic maps generated from ArcGIS comparing mass shooting events from 2019 (white circles) and 2020 (black circles) for six major US cities: A. St. Louis, B. New Orleans, C. Philadelphia, D. Chicago, E. Detroit, F. Baltimore.

violence were not evaluated and it is hard to draw conclusions from different cities. Additional inquiry is needed to understand the role of the pandemic upon gun violence in smaller cities that did not previously experience high burdens of mass shooting events.

Conclusions

Increasing violence in United States cities after the COVID-19 pandemic represents an evolving trend as local and national regulations change. Solutions are needed to tackle both the social factors and widespread firearm access in urban communities in order to reduce the incidence of mass shootings events. Data reflect a general consistency yet augmentation in gun violence, indicating heightened urgency for previously validated interventions: the existing efficacious interventions that may impact gun violence should continue to be efficacious post-pandemic.

Author contributions

AAS: Study design, data analysis, and writing of the manuscript
TFS: Data analysis and writing of the manuscript
KB: Study design and data analysis
ACC: Data analysis and writing of the manuscript
PS: Study design, data analysis, and writing of the manuscript
JS: Study design and critical revisions of the manuscript
LS: Study design and critical revisions of the manuscript
PG: Study design and critical revisions of the manuscript
AM: Study design and critical revisions of the manuscript
AT: Study design and data analysis
JPH: Study design and critical revisions of the manuscript

Declaration of Competing Interest

AS is a paid consultant for Aroa Biologics. PG is a paid consultant and speaker for Zimmer Biomet and DePuy Synthes. The other authors declare no conflicts of interest.

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